Precision Horticulture: Technology Development and Research and Management Applications

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Introduction

Precision farming is information-based management techniques that have the potential to increase productivity and reduce environmental pollution. Recent studies have determined that accurate yield monitoring is a key element in precision farming. Studies showed that it is possible to reduce fertilizer input and maintain yield under site-specific nutrient management.

Yield is the primary determinant of nutrient demand and uptake efficiency and therefore, fertilizer needs. In tree crops, however, yields vary dramatically from tree to tree within an orchard and between orchards making accurate fertilizer recommendations impossible. Given this fundamental limitation, it has been

impossible to develop truly efficient orchard fertilizer management systems or to conduct nutritional research experiments properly. Our inability to determine tree yield on a scale smaller than the standard block or orchard, severely impedes our ability to optimize productivity and minimize costs.

The ability to map yield in an orchard and to use that information to optimize inputs would revolutionize tree crop industries and directly contribute to improved resource use efficiency. The most direct benefit of this approach would be the ability to optimize fertilization strategies on a site-specific basis. This is the key to improve nutrient use efficiency.

This project aims to develop the means to rapidly harvest and map pistachio tree yields in commercial orchards on a tree-by-tree basis by integrating Global Positioning System (GPS) and yield monitors into the harvesting machinery. This will be followed by development of statistical and visual computational methodology to analyze and map results. Soil and plant testing will be used to determine the cause of the yield variability and experimental manipulations will be conducted to optimize yield and management efficiency. The lessons learned in this project will then be extended to all tree crops in California.

Objectives

The aim of the project is to develop the harvesting machinery, initiate statistical and mapping methodologies to allow growers to view and interpret the annual productivity of each tree in their orchards. This will then be used to optimize management strategies and to improve on-farm research capability.
The specific objectives are:

1. To develop technology to allow large-scale, tree-to-tree yield analysis.
2. To utilize this technology to determine the factors that contribute to yield variability including development of statistical, mapping, and biological interpretations.
3. To conduct a demonstration research project utilizing these technologies.
4. To conduct workshops to demonstrate the technology.

Project Description

In the first year, 2001, we selected an 80 acre pistachio orchard containing 12,000 trees located at the Paramount Farming Company, Lost Hills California. This orchard was 12 years old, uniform in appearance and with a good production history. Global Positioning System and Geographic Information System technologies were used to determine tree-by-tree yield.

Results and Discussion

In 2001, Texture and Compaction Index (TCI) (Fig.1) and Electrical Conductivity (EC) (Fig. 2), were made using GPS-sensor- based systems. A new electronic weigh bucket was designed (Fig. 3). The harvesting equipment for pistachio was modified to include the electronic weigh bucket system (Fig. 4) to allow real-time tree-by-tree harvest data. This system was then mounted on the bank-out wagon

and a mass flow tree harvesting was performed. In addition, soil and leaf samples were taken to analyze the soil fertility and leaf nutrition status.
The harvesting equipment developed was shown to be rugged and reliable. Problems with GPS determinations in the field persist and will require further engineering improvements to resolve. A primary constraint to the current yield monitor is the inability to completely clear the catch frame of harvested nuts prior to harvest of the following tree. This problem results in mixing of yields and loss of tree-to-tree resolution. This represents an engineering challenge that can be addressed with a slightly modified harvesting system.

The data collected this year provides excellent information at a resolution of about 5 x 5 trees. A higher degree of resolution is possible utilizing mathematical procedures and through engineering refinements. We have commenced GIS analysis of yield and variation in environment (Soil, water, nutrition)– this will be presented at the annual conference.

Tree Yield Varies Dramatically Across the Orchard

Tree yield varies dramatically within a single row (Fig 5) and yield variations of > 200% between 5 neighboring trees is not uncommon. Tree yield varies markedly over the orchard as a whole (Fig 6), and regional per acre yields varied from 9000 lbs per acre (in-field, in-hull) in the poorest area to 17000 lbs per acre (in-field, in-hull) in the best area.
The results presented here demonstrate that yield is highly variable in Pistachio. It should be remembered however that this is only the first year of analysis. Data from the second year is being analyzed and a second year is essential to correct for alternate bearing effects. The challenge for a grower and for a researcher is to determine what are the causes of this yield variation and what can be done to optimize profitability.

Data of the current year, 2002, was collected and is being analyzed. Eighty acres were harvested and yield of 6040 trees were determined on tree-by-tree basis. This data was collected using modified harvesting machinery based on our learning experience from last year. The machinery modification includes an increase of 50 % in the capacity of the Weight Bucket, higher speed of the conveyer belt, efficient cleaning system by reducing the transport lag phase. The transport lag phase allowed determination of tree-by-tree yield without a significant yield carry-over from the previous tree. Also, a GPS-radar system was integrated into the system to determine accurately the position of the harvested tree. The details of the modified system will be discussed at the tenth annual conference. Conclusions will be made once the data is analyzed. Therefore, it is too early yet to define which variables are most important though preliminary information may indicate that the source of variation could be due to a combination of soil and biological system variables. By comparing patterns of yield and measured soil and biological system variables, a greater understanding of the crop conditions and potential causes of yield variability can be gained.